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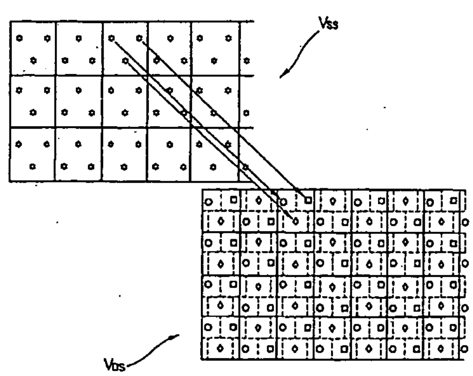
(54) Method of fast processing image data for improving image visibility

(57) A method of processing image data to generate output image data for driving a display panel is provided. In the method, a new resolution for input image data is set according to a resolution of the display panel. A first virtual screen is divided into a plurality of pixel areas according to the new resolution set for the input image data. A second virtual screen having a sub-pixel array structure of the display panel is superimposed on the first virtual screen. A mask wider than a sub-pixel area on the superimposed second virtual screen is laid on each sub-pixel area. An area ratio of the area of each pixel portion on the first virtual screen included in each mask to the area of the mask is obtained and set. The new resolution and the area ratios are applied to a driving device of the display panel. The input image data having an original resolution is transformed into image data having the new resolution. The sum of the results of multiplying an area ratio of the area of each pixel portion on the first virtual screen included in each mask by the transformed image data of the pixel areas, respectively, is generated as output image data of a sub-pixel corresponding to the mask.

FIG. 3



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Description

[0001] The present invention relates to a method of processing image data, and more particularly, to a method of processing input image data to generate output image data for driving a display panel.

[0002] A general method of processing image data includes a first virtual screen, which is divided into a plurality of pixel areas according to the resolution of input image data, and a second virtual screen having a sub-pixel array of a display panel. The second virtual screen includes red sub-pixel areas, green sub-pixel areas, and blue sub-pixel areas.

[0003] Input image data has only position information of a unit pixel but does not have position information of sub-pixels, *i.e.*, a red sub-pixel, a green sub-pixel, and a blue sub-pixel, constituting the unit pixel. However, the positions of sub-pixels are different in different pixel areas in any display panel. Moreover, for two adjacent pixels, a distance between red sub-pixels, a distance between green sub-pixels, and a distance between blue sub-pixels are different from one another. Accordingly, visibility of images displayed on display panels is degraded.

[0004] A technique related to the visibility of an image is disclosed in U.S. Patent No. 5,341,153 for *Method and Apparatus for Displaying a Multicolor Image* by Benzschawel et al. According to this technique, input image data having a high resolution is directly superimposed on a display panel having a low resolution. This technique cannot radically solve the image visibility problem of a display panel due to a sub-pixel array structure. Moreover, since an input image data transforming operation is individually performed for all of the sub-pixels of a display panel, display speed decreases.

[0005] In order to accomplish the above and other objects, according to an aspect of the present invention, there is provided a method of processing image data to generate output image data for driving a display panel. In the method, a new resolution for input image data is set according to a resolution of the display panel. A first virtual screen is divided into a plurality of pixel areas according to the new resolution set for the input image data. A second virtual screen having a sub-pixel array structure of the display panel is superimposed on the first virtual screen. A mask wider than a sub-pixel area on the superimposed second virtual screen is laid on each sub-pixel area. An area ratio of the area of each pixel portion on the first virtual screen included in each mask to the area of the mask is obtained and set. The new resolution and the area ratios are applied to a driving device of the display panel. The input image data having an original resolution is transformed into image data having the new and enhanced resolution. The sum of the results of multiplying an area ratio of the area of each pixel portion on the first virtual screen included in each mask by the transformed image data of the pixel areas, respectively, is generated as output image data of a sub-pixel corresponding to the mask.

[0006] The present invention thus provides a method of processing image data which aims to fundamentally solve the problem of image visibility due to the sub-pixel array structure of a display panel with the minimum number of input image data transforming operations.

[0007] Image data is processed by providing a new resolution for input image data that is set in order to maximize the number of masks having the same area ratio structures and accordingly, the number of masks to be used is minimized, so the number of times area ratios are multiplied by transformed image data is minimized, thereby increasing display speed and decreasing necessary memory-capacity.

[0008] By processing image data by having each sub-pixel of a display panel involved with the data of its adjacent pixels on a first virtual screen, so a problem in reproducing an image due to the sub-pixel array structure of the display panel can be radically solved.

[0009] The invention also may correct a color error, which may occur during data processing.

[0010] The method of processing image data according to the present invention has the following effects.

[0011] First, a new resolution for input image data can be set in order to maximize the number of masks having the same area ratio structures. Accordingly, the number of masks to be used is minimized, so the number of times area ratios are multiplied by transformed image data is minimized, thereby increasing display speed and decreasing necessary memory-capacity.

[0012] Second, each sub-pixel of a display panel is involved with the data of its adjacent pixels on a first virtual screen, so a problem in reproducing an image due to the sub-pixel array structure of the display panel can be radically solved.

[0013] A more complete appreciation of the invention, and many of the attendant advantages thereof, will be readily apparent as the same becomes better understood by reference to the following detailed description when considered in conjunction with the accompanying drawings in which like reference symbols indicate the same or similar components, wherein:

FIG. 1 shows the principle of a conventional method of processing image data;
FIG. 2 is a diagram for sub-pixel rendering methodology;
FIG. 3 shows the principle of a method of processing image data according to the present invention;
FIG. 4 is a flowchart of a method of processing image data according to an embodiment of the present invention;

FIG. 5 shows an example of a first virtual screen resulting from step S2 shown in FIG. 4;
FIG. 6 shows an example of the superimposition of virtual screens resulting from step S3 shown in FIG. 4 when a ratio of a new resolution of input image data to the resolution of a display panel is 1:1;
FIG. 7 shows an example of the superimposition of virtual screens resulting from step S3 shown in FIG. 4 when a ratio of a new resolution of input image data to the resolution of a display panel is 1.5:1;
FIG. 8A shows an example of the superimposition of virtual screens on which a quadrilateral mask is laid on each blue sub-pixel area as the result of performing step S4 shown in FIG. 4 when a ratio of a new resolution of input image data to the resolution of a display panel is 1.5:1;
FIG. 8B shows an enlarged view of a hatched mask area shown in FIG. 8A in order to explain an algorithm used in step S5 shown in FIG. 4;
FIG. 9A shows an example of the superimposition of virtual screens on which a hexagonal mask is laid on each blue sub-pixel area as the result of performing step S4 shown in FIG. 4 when a ratio of a new resolution of input image data to the resolution of a display panel is 1.5:1;
FIG. 9B shows an enlarged view of a hatched mask area shown in FIG. 9A in order to explain another algorithm used in step S5 shown in FIG. 4;
FIG. 10A shows an example of the superimposition of virtual screens on which a circular mask is laid on each blue sub-pixel area as the result of performing step S4 shown in FIG. 4 when a ratio of a new resolution of input image data to the resolution of a display panel is 1.5:1;
FIG. 10B shows an enlarged view of a hatched mask area shown in FIG. 10A in order to explain still another algorithm used in step S5 shown in FIG. 4;
FIG. 11 shows sub-pixel areas on a second virtual screen, which are disposed at different horizontal and vertical positions with respect to unit pixel areas on a first virtual screen when a ratio of a new resolution of input image data to the resolution of a display panel is 1.4:1;
FIG. 12 shows sub-pixel areas on a second virtual screen, which are disposed at different horizontal and vertical positions in different unit pixel areas on a first virtual screen when a ratio of a new resolution of input image data to the resolution of a display panel is 1.5:1;
FIG. 13A is a graph of the number of different horizontal positions with respect to a horizontal resolution ratio when the sub-pixel areas of a display panel have a delta structure;
FIG. 13B is a graph of the number of different vertical positions with respect to a vertical resolution ratio when the sub-pixel areas of a display panel have a delta structure;
FIG. 14 is a graph of the number of masks with respect to a resolution ratio when the sub-pixel areas of a display panel have a striped structure;
FIG. 15 is a graph of the number of masks with respect to a resolution ratio when the sub-pixel areas of a display panel have a delta structure;
FIG. 16A shows a state in which the central line of a pixel area on a first virtual screen is the central line of a sub-pixel area on a second virtual screen;
FIG. 16B shows a state in which the central line of a pixel area on a first virtual screen is not the central line of a sub-pixel area on a second virtual screen; and
FIG. 17 through 19 show examples of devices including displays using the techniques of the present invention.

[0014] FIG. 1 shows the principle of a general method of processing image data. A reference character V_{SS} denotes a first virtual screen, which is divided into a plurality of pixel areas according to the resolution of input image data. A reference character V_{DS} denotes a second virtual screen having a sub-pixel array of a display panel. On the second virtual screen V_{DS}, areas having a circle at their center are red sub-pixel areas, areas having a square at their center are green sub-pixel areas, and areas having a diamond at their center are blue sub-pixel areas.

[0015] Referring to FIG. 1, input image data has only position information of a unit pixel but does not have position information of sub-pixels, *i.e.*, a red sub-pixel, a green sub-pixel, and a blue sub-pixel, constituting the unit pixel. However, the positions of sub-pixels are different in different pixel areas in any display panel. Moreover, for two adjacent pixels, a distance between red sub-pixels, a distance between green sub-pixels, and a distance between blue sub-pixels are different from one another. Accordingly, visibility of images displayed on display panels is degraded.

[0016] Referring to the diagram of FIG. 2, sub-pixel rendering methodology includes checking input signal resolution (step A10). After checking the input signal resolution, the input resolution conversion is made to one of the optimum sub-pixel rendering ratios (step A12). After step A 12, the mask shape is decided (step A 14). The relative laying position of the mask to the first virtual screen is also decided (step A16). Tables proportionate to the area of the divided mask by the first virtual screen are obtained (step A18). The sub pixel values are calculated according to the tables (step A20). Finally, the color checked for any errors and the output image is checked (step A22).

[0017] FIG. 3 shows the principle of a method of processing image data according to the present invention. A reference character V_{SS} denotes a first virtual screen, which is divided into a plurality of pixel areas according to a new

resolution of input image data. A reference character V_{DS} denotes a second virtual screen having a sub-pixel array of a display panel. On the second virtual screen V_{DS}, areas having a circle at their center are red sub-pixel areas, areas having a square at their center are green sub-pixel areas, and areas having a diamond at their center are blue sub-pixel areas.

[0018] FIG. 4 shows a method of processing image data according to an embodiment of the present invention. In FIG. 4, steps S 1 through S5 indicate steps of setting a resolution and an area ratio during manufacture of a display driving device. The method of processing image data according to an embodiment of the present invention will be schematically described with reference to FIGS. 3 and 4.

[0019] A new resolution for input image data is set according to the resolution of a display panel in step S1. Here, a new horizontal resolution and a new vertical resolution are set. The new horizontal resolution for the input image data is set according to the horizontal resolution of the display panel, and the new vertical resolution for the input image data is set according to the vertical resolution of the display panel.

[0020] The first virtual screen V_{SS} is divided into a plurality of pixel areas according to the new resolution of the input image data in step S2. The second virtual screen V_{DS} having the sub-pixel array structure of a display panel is superimposed on the first virtual screen V_{SS} in step S3. A mask, which is wider than each sub-pixel area of the display panel on the superimposition of the virtual screens V_{DS}-V_{SS}, is laid on each cell area of the display panel in step S4. It is also preferable that the mask does not include the next same color sub-pixel. For example, if the mask includes a first color sub-pixel, then the mask should not touch or include the next sub-pixel having also the first color. As another example, the mask may include only one of each sub-pixel color. An area ratio table showing the ratio of the area of each pixel portion of the first virtual screen V_{SS} in each mask to the area of the mask, is obtained and set in step S5. In step S6, the resolution set in step S1 and the area ratio table set in step S5 are applied to a driving device of the display panel, the input image data is transformed so that the original resolution of the input image data is changed into the new resolution set in step S1, and then the sum of the results of multiplying the ratio of the area of each pixel portion included in each mask to the area of the mask by the transformed image data is generated as output image data of a sub-pixel corresponding to the mask. In other words, each sub-pixel of the display panel is involved with the data of its adjacent pixels on the first virtual screen V_{SS}. Accordingly, as shown in FIG. 3, the input image data of the first virtual screen V_{SS} can be corrected to be suitable to the sub-pixel array structure of the display panel, thereby radically solving a problem in image visibility due to the sub-pixel array structure of the display panel.

[0021] In addition, in step S1 the new resolution for the input image data is set to maximize the number of masks having the same area ratio structures in step S5, so the number of masks used in step S4 is minimized. Consequently, the number of times the area ratios are multiplied by the transformed image data is minimized.

[0022] Referring to FIG. 5, when step S2 shown in FIG. 4 is performed, the first virtual screen V_{SS} is divided into a plurality of pixel areas VP_{11} through $VP_{6(10)}$ according to the new resolution set for the input image data.

[0023] FIG. 6 shows an example of the superimposition of the virtual screens V_{DS}-V_{SS} resulting from step S3 shown in FIG. 4 when a ratio of the new resolution of the input image data to the resolution of the display panel is 1:1. In FIG. 6, reference characters CR_{12} through CR_{33} denote red sub-pixel areas, reference characters CG_{11} through CG_{33} denote green sub-pixel areas, and reference characters CB_{11} through CB_{33} denote blue sub-pixel areas. Referring to FIG. 6, the second virtual screen V_{DS} having a delta structure as the sub-pixel array structure of the display panel is superimposed on the first virtual screen V_{SS}. In other words, the second virtual screen V_{DS} divided into plurality of sub-pixel areas CG_{11} through CR_{33} is superimposed on the first virtual screen V_{SS} divided into a plurality of pixel areas VP_{15} through VP_{47}.

[0024] FIG. 7 shows an example of the superimposition of the virtual screens V_{DS}-V_{SS} resulting from step S3 shown in FIG. 4 when a ratio of the new resolution of the input image data to the resolution of the display panel is 1.5:1. In FIG. 7, areas defined by solid lines are pixel areas on the first virtual screen V_{SS}, and areas defined by dotted lines are sub-pixel areas on the second virtual screen V_{DS}. On the second virtual screen V_{DS}, areas having a circle at their center are red sub-pixel areas, areas having a square at their center are green sub-pixel areas, and areas having a diamond at their center are blue sub-pixel areas.

[0025] FIG. 8A shows an example of the superimposition of the virtual screens V_{DS}-V_{SS} on which a quadrilateral mask is laid on each blue sub-pixel area as the result of performing step S4 shown in FIG. 4 when a ratio of the new resolution of the input image data to the resolution of the display panel is 1.5:1. After step S4 shown in FIG. 4 is performed, step S5 shown in FIG. 4 is performed. In other words, for each mask, the ratio of the area of each pixel portion of the first virtual screen V_{SS} included in the mask to the area of the mask is obtained and set. FIG.8B shows an enlarged view of a hatched mask M_{nm} shown in FIG. 8A in order to explain an algorithm used in step S5 shown in FIG. 4. The mask M_{nm} is for a blue sub-pixel at an n-th place in a horizontal direction and an m-th place in a vertical direction. In FIG. 8B, a reference character A_{LU} denotes the area of an upper left pixel portion, a reference character A_{RU} denotes the area of an upper right pixel portion, a reference character ALL denotes the area of a lower left pixel portion, and a reference character A_{RL} denotes the area of a lower right pixel portion. Accordingly, an area ratio of the area of each pixel portion of the first virtual screen V_{SS} included in the blue sub-pixel mask M_{nm} to the area of the blue

sub-pixel mask M_{nm} is obtained using the areas A_{LU}, A_{RU}, A_{LL}, and A_{RL} and a unit mask area $A_{LU} + A_{RU} + A_{LL} + A_{RL}$. In step S6, output image data b_{mn} for the blue sub-pixel shown in FIG. 8B is obtained using Formula (1).

$$b_{mn} = \frac{A_{LU} \cdot b_{LU} + A_{RU} \cdot b_{RU} + A_{LL} \cdot b_{LL} + A_{RL} \cdot b_{RL}}{A_{LU} + A_{RU} + A_{LL} + A_{RL}} \quad (1)$$

[0026] In Formula (1), b_{LU} indicates blue image data of a pixel area including the area A_{LU} on the first virtual screen V_{SS}, b_{RU} indicates blue image data of a pixel area including the area A_{RU} on the first virtual screen V_{SS}, b_{LL} indicates blue image data of a pixel area including the area A_{LL} on the first virtual screen V_{SS}, and b_{RL} indicates blue image data of a pixel area including the area A_{RL} on the first virtual screen V_{SS}.

[0027] Accordingly, the input image data of the first virtual screen V_{SS} can be corrected to be suitable to the sub-pixel array structure of the display panel, thereby radically solving a problem in image visibility due to the sub-pixel array structure of the display panel.

[0028] FIG. 9A shows an example of the superimposition of the virtual screens V_{DS}-V_{SS} on which a hexagonal mask is laid on each blue sub-pixel area as the result of performing step S4 shown in FIG. 4 when a ratio of the new resolution of the input image data to the resolution of the display panel is 1.5:1. After step S4 shown in FIG. 4 is performed, step S5 shown in FIG. 4 is performed. In other words, for each mask, the ratio of the area of each pixel portion of the first virtual screen V_{SS} included in the mask to the area of the mask is obtained and set. FIG. 9B shows an enlarged view of a hatched mask M_{nm} shown in FIG. 9A in order to explain another algorithm used in step S5 shown in FIG. 4. The mask M_{nm} is for a blue sub-pixel at an n-th place in a horizontal direction and an m-th place in a vertical direction. In FIG. 9B, a reference character A_1 denotes the area of a first pixel portion, a reference character A_2 denotes the area of a second pixel portion, a reference character A_3 denotes the area of a third pixel portion, a reference character A_4 denotes the area of a fourth pixel portion, a reference character A_5 denotes the area of a fifth pixel portion, and a reference character A_6 denotes the area of a sixth pixel portion. Accordingly, an area ratio of the area of each pixel portion of the first virtual screen V_{SS} included in the blue sub-pixel mask M_{nm} to the area of the blue sub-pixel mask M_{nm} is obtained using the areas A_1, A_2, A_3, A_4, A_5, and A_6 and a unit mask area $A_1 + A_2 + A_3 + A_4 + A_5 + A_6$. In step S6, output image data b_{mn} for the blue sub-pixel shown in FIG. 9B is obtained using Formula (2).

$$b_{mn} = \frac{A_1 \cdot b_1 + A_2 \cdot b_2 + A_3 \cdot b_3 + A_4 \cdot b_4 + A_5 \cdot b_5 + A_6 \cdot b_6}{A_1 + A_2 + A_3 + A_4 + A_5 + A_6} \quad (2)$$

[0029] In Formula (2), b_1 indicates blue image data of a pixel area including the area A_1 on the first virtual screen V_{SS}, b_2 indicates blue image data of a pixel area including the area A_2 on the first virtual screen V_{SS}, b_3 indicates blue image data of a pixel area including the area A_3 on the first virtual screen V_{SS}, b_4 indicates blue image data of a pixel area including the area A_4 on the first virtual screen V_{SS}, b_5 indicates blue image data of a pixel area including the area A_5 on the first virtual screen V_{SS}, and b_6 indicates blue image data of a pixel area including the area A_6 on the first virtual screen V_{SS}.

[0030] Accordingly, the input image data of the first virtual screen V_{SS} can be corrected to be suitable to the sub-pixel array structure of the display panel, thereby radically solving a problem in image visibility due to the sub-pixel array structure of the display panel.

[0031] Stated in another way, formula 2 can be shown with the output image data b_{mn} for the blue sub-pixel shown in FIG. 9B being obtained using Formula (3).

$$b_{mn} = \frac{\sum_{y=1}^{z} A_y \cdot b_y}{\sum_{y=1}^{z} A_y} \quad \ldots(3)$$

[0032] In Formula (3), "A" indicates an area of a portion of the mask, z is the number of portions of the mask, and b is the image data of a pixel area including the area A on the first virtual screen. Therefore, y is an integer from 1 to the total number of portions z of the mask.

[0033] FIG. 10A shows an example of the superimposition of the virtual screens V_{DS}-V_{SS} on which a circular mask is laid on each blue sub-pixel area as the result of performing step S4 shown in FIG. 4 when a ratio of the new resolution of the input image data to the resolution of the display panel is 1.5:1. FIG. 10B shows an enlarged view of a hatched mask M_{nm} shown in FIG. 10A in order to explain an algorithm used in step S5 shown in FIG. 4. The mask M_{nm} is for a blue sub-pixel at an n-th place in a horizontal direction and an m-th place in a vertical direction. In FIG. 10B, a reference character A_{LU} denotes the area of an upper left pixel portion, a reference character A_{RU} denotes the area of an upper right pixel portion, a reference character A_{LL} denotes the area of a lower left pixel portion, and a reference character A_{RL} denotes the area of a lower right pixel portion. The description of FIGS. 10A and 10B is the same as that of FIGS. 8A and 8B, and is thus omitted. Meanwhile, circular masks are ideal in theory, but in practice some pixel areas are used twice and some pixel areas are not used at all in obtaining output image data. Accordingly, circular masks are less preferable than quadrilateral and hexagonal masks. However, it is preferable that the shape of masks is the same as the shape of sub-pixels of a display panel.

[0034] FIG. 11 shows sub-pixel areas on the second virtual screen V_{DS}, which are disposed at different horizontal and vertical positions with respect to unit pixel areas on the first virtual screen V_{SS} when a ratio of the new resolution of the input image data to the resolution of the display panel is 1.4:1. In FIG. 11, areas defined by solid lines are pixel areas on the first virtual screen V_{SS}, and areas defined by dotted lines are sub-pixel areas on the second virtual screen V_{DS}. On the second virtual screen V_{DS}, areas having a circle at their center are red sub-pixel areas, areas having a square at their center are green sub-pixel areas, and areas having a diamond at their center are blue sub-pixel areas. Referring to FIG. 11, the number of different horizontal positions of sub-pixel areas is 15, and the number of different vertical positions thereof is 10. In other words, 150 masks must be used in step S4 shown in FIG.4. Accordingly, in step S6, the number of times , that area ratios are multiplied by transformed image data, relatively increases, thereby decreasing display speed and increasing necessary memory-capacity.

[0035] FIG. 12 shows sub-pixel areas on the second virtual screen V_{DS}, which are disposed at different horizontal and vertical positions with respect to unit pixel areas on the first virtual screen V_{SS} when a ratio of the new resolution of the input image data to the resolution of the display panel is 1.5:1. In FIG. 12, areas defined by solid lines are pixel areas on the first virtual screen V_{SS}. On the second virtual screen V_{DS}, areas having a circle at their center are red sub-pixel areas, areas having a square at their center are green sub-pixel areas, and areas having a diamond at their center are blue sub-pixel areas. Referring to FIG. 12, the number of different horizontal positions of sub-pixel areas is 0, and the number of different vertical positions thereof is 4. In other words, only 4 masks are used in step S4 shown in FIG. 4. Accordingly, in step S6, the number of times area ratios are multiplied by transformed image data decreases, thereby increasing display speed. For example, an area ratio table shown in Table 1 is obtained in step S5 shown in FIG. 4.

Table 1

		Pixel-area positions						Sums	
		1	2	3	4	5	6	7	
Masks	A	2	1	16	8	6	3		36
	B	10	5	14	7				36
	C	7	14	5	10				36
	D	3	6	8	16	1	2		36

[0036] Here, the mask shown in FIG. 8B corresponds to the mask C in Table 1. Referring to FIG. 8B and mask C in Table 1, the area A_{LL} has area ratio of 7, the area A_{RL} has area ratio of 14, the area A_{LU} has area ratio of 5, and the area A_{RU} has area ratio of 10.

[0037] Therefore, it can be inferred from FIGS. 11 and 12 that the number of masks to be used is minimized by performing step S1 shown in FIG. 4.

[0038] FIG. 13A is a graph of the number of different horizontal positions with respect to a horizontal resolution ratio when the sub-pixel areas of a display panel have a delta structure. Here, the delta structure is a sub-pixel array structure shown in the second virtual screen V_{DS} of FIG. 3. Referring to FIG. 13A, it is preferable to set a new horizontal resolution for input image data such that a ratio of the new horizontal resolution to the horizontal resolution of the display panel is 1:1, 1.5:1, or 2:1.

[0039] FIG. 13B is a graph of the number of different vertical positions with respect to a vertical resolution ratio when the sub-pixel areas of a display panel have a delta structure. Referring to FIG. 13B, it is preferable to set a new vertical resolution for input image data such that a ratio of the new vertical resolution to the vertical resolution of the display panel is 1:1, 1.2:1, 1.5:1, 1.6:1, or 2:1.

[0040] FIG. 14 is a graph of the number of masks with respect to a resolution ratio when the sub-pixel areas of a display panel have a striped structure. In this case, a resolution ratio means a vertical resolution ratio and a horizontal resolution ratio which are the same. In the striped structure, red sub-pixel areas are positioned on a first line, green sub-pixel areas are positioned on a second line, and blue sub-pixel areas are positioned on a third line. The detailed data of the graph shown in FIG. 14 is shown in Tables 2A through 2C.

Table 2A

resolution ratio	1:1	1.1:1	1.2:1	1.3:1	1.4:1	1.5:1
Number of masks	3	300	25	300	75	4

Table 2B

resolution ratio	1.6:1	1.7:1	1.8:1	1.9:1	2.0:1	2.1:1
Number of masks	75	Over 1000	25	Over 1000	3	100

Table 2C

resolution ratio	2.2:1	2.3:1	2.4:1	2.5:1	2.6:1	---------
Number of masks	75	300	500	12	75	---------

[0041] A delta type structure of the sub-pixel areas of a display panel is more preferable than a striped structure because in a stripe type structure, the sub-pixels that are located on the up and down side of a certain sub-pixel are of the same color so that the first imaginary image cells which are vertically located of a certain sub-pixel and overlapped by a mask are less effective to the sub-pixel in the process of sub-pixel rendering than delta type structure.

[0042] FIG. 15 is a graph of the number of masks with respect to a resolution ratio when the sub-pixel areas of a display panel have a delta structure. In this case, a resolution ratio means a vertical resolution ratio and a horizontal resolution ratio which are the same. The detailed data of the graph shown in FIG. 15 is shown in Tables 3A through 3C.

Table 3A

resolution ratio	1:1	1.1:1	1.2:1	1.3:1	1.4:1	1.5:1
Number of masks	6	300	25	300	150	4

Table 3B

resolution ratio	1.6:1	1.7:1	1.8:1	1.9:1	2.0:1	2.1:1
Number of masks	75	Over 2000	25	Over 2000	3	100

Table 3C

resolution ratio	2.2:1	2.3:1	2.4:1	2.5:1	2.6:1	---------
Number of masks	150	300	500	12	150	---------

[0043] In the meantime, when a second virtual screen is superimposed on a first virtual screen, it is preferable that the central line of each pixel area on the first virtual screen is not the central line of each sub-pixel area on the second virtual screen. The reason will be described below.

[0044] FIG. 16A shows a state in which the central line of a pixel area on a first virtual screen is the central line of a sub-pixel area on a second virtual screen. FIG. 16B shows a state in which the central line of a pixel area on a first virtual screen is not the central line of a sub-pixel area on a second virtual screen. In FIGS. 16A and 16B, reference characters VP_{11} through VP_{23} denote some pixel areas on the first virtual screen. A reference character CR_{22} denotes a red sub-pixel area on the second virtual screen, a reference character CG_{22} denotes a green sub-pixel area on the second virtual screen, and a reference character CB_{22} denotes a blue sub-pixel area on the second virtual screen. A reference character MR_{22} denotes a mask for the red sub-pixel area CR_{22}, a reference character MG_{22} denotes a

mask for the green sub-pixel area CG_{22}, and a reference character MB_{22} denotes a mask for the blue sub-pixel area CB_{22}.

[0045] Referring to FIG. 16A, the central vertical line of a pixel area on the first virtual screen is the central vertical line of the green sub-pixel area CG_{22} on the second virtual screen. When steps S4, S5, and S6 are performed in this state, a color error phenomenon in which green is visually conspicuous may occur. When green is conspicuous, a viewer may easily notice the color error phenomenon.

[0046] However, as shown in FIG. 16B, when the central vertical line of a pixel area on the first virtual screen is a middle line between the green and blue sub-pixel areas CG_{22} and CB_{22} on the second virtual screen, a mixture of green and blue, *i.e.*, a shade of cyan, may be visually conspicuous. When a shade of cyan is conspicuous, a viewer cannot easily recognize the color error phenomenon.

[0047] Similarly, when the central vertical line of a pixel area on the first virtual screen is a middle line between the red and blue sub-pixel areas CR_{22} and CB_{22} on the second virtual screen, a mixture of red and blue, *i.e.*, a shade of magenta, may be visually conspicuous. When a shade of magenta is conspicuous, a viewer cannot easily recognize the color error phenomenon.

[0048] In the meantime, referring to FIGS. 8A and 12, when a ratio of the new resolution of the input image data to the resolution of the display panel is 1.5:1, the central vertical line of a pixel area on the first virtual screen V_{SS} is not the central vertical line of a sub-pixel area on the second virtual screen V_{DS}.

[0049] The present invention is applicable to all types of display devices including for example plasma display panels (PDP), liquid crystal display (LCD) panels and ferroelectric liquid crystal (FLC) panels.

[0050] Devices that can be used for applying the present invention can include for example televisions, computers, and other multimedia or telecommunication devices. For example, as seen in FIG. 17 a device for processing image data to generate output image data for driving a display panel according to the present invention can include the display panel such as a plasma display panel 100 connected to a display controller 102 and a display memory 104. The processor or controller 106 processes the image data stored in the image memory 108 and transfers the processed image data to the display memory 104 where the transferred data is managed by the display controller 102 for display on the display panel 100.

[0051] FIG. 18 shows another view of a device for processing image data to generate output image data for driving a display panel according to the present invention. The display panel 100 is controlled by controller 112 using memory or computer readable media 114 (*e.g.* non volatile read-only memory, random access memory, floppy disks, compact discs, digital versatile discs, hard disk drives, flash read-only memories, other optical and magnetic mediums, *etc.*).

[0052] Referring to FIG. 19, another example of a device implementing the present invention is a display device unit 150 connected to a computer unit 200 and the computer unit 200 is connected to a remote computer 300. The display panel 100 such as a plasma display panel is driven by a display driving unit 120 and is connected to the computer unit 200 through the interface 130 of the display unit 150 and display interface 210 of the computer unit 200. Through a system bus, the display interface 210 is connected to computer readable media such as the system memory 220 (read-only memory, random access memory) and storage media 240 (floppy disks, compact discs, digital versatile discs, hard disk drives, flash read-only memories, other optical and magnetic mediums, *etc.*). The system bus also connects the computer processor 230 with the computer readable medium and includes inputs through input device 262 and other input and output devices 260. The computer unit 200 can also be connected to a remote computer 300 through a network interface 250 and a network 400 such as the Internet.

[0053] As described above, a method of processing image data according to the present invention has the following effects.

[0054] First, a new resolution for input image data can be set in order to maximize the number of masks having the same area ratio structures. Accordingly, the number of masks to be used is minimized, so the number of times area ratios are multiplied by transformed image data is minimized, thereby increasing display speed and decreasing necessary memory-capacity.

[0055] Second, each sub-pixel of a display panel is involved with the data of its adjacent pixels on a first virtual screen, so a problem in reproducing an image due to the sub-pixel array structure of the display panel can be radically solved.

[0056] In addition, a color error, which may occur during data processing, can be corrected.

[0057] The present invention is not restricted to the above-described embodiment, and it will be apparent that various changes can be made by those skilled in the art without departing from the spirit of the invention.

Claims

1. A method of processing image data to generate output image data for driving a display panel, the method comprising:

setting a new resolution for input image data according to a resolution of said display panel;
dividing a first virtual screen into a plurality of pixel areas according to said new resolution set for said input image data;
superimposing a second virtual screen including a sub-pixel array structure of said display panel on said first virtual screen;
laying a mask wider than a sub-pixel area on the superimposed second virtual screen on each sub-pixel area;
obtaining and setting an area ratio of the area of each pixel portion on said first virtual screen included in each mask to an area of said mask; and
applying said new resolution and the area ratios to a driving device of said display panel, transforming said input image data having an original resolution into image data having said new resolution, and generating a sum of the results of multiplying area ratios of pixel portions on the first virtual screen in each mask by the transformed image data of the pixel areas, respectively, as output image data of the sub-pixel corresponding to said mask.

2. The method of claim 1, with the new resolution for the input image data being set to maximize the number of masks having the same area ratio structures.

3. The method of claim 2, with the setting of said new resolution comprising:

setting a new horizontal resolution for said input image data according to a horizontal resolution of said display panel; and
setting a new vertical resolution for said input image data according to a vertical resolution of said display panel.

4. The method of claim 3, with said new horizontal resolution being set to accommodate a ratio of said new horizontal resolution for the input image data to said horizontal resolution of said display panel being one among 1:1, 1.5:1, and 2:1.

5. The method of claim 3, with said new vertical resolution being set to accommodate said new vertical resolution for said input image data to said vertical resolution of said display panel being one among 1:1, 1.2:1, 1.5:1, 1.6:1, and 2:1.

6. The method of any preceding claim wherein, when said second virtual screen is superimposed on said first virtual screen, the central line of each pixel area on said first virtual screen is not the central line of each sub-pixel area on said second virtual screen.

7. The method of any preceding claim wherein the shape of said masks is the same as said sub-pixels of said display panel.

8. The method of any of claims 1 to 7, wherein the shape of said masks is one among a quadrilateral, a hexagon, and a circle.

9. The method of claim 8 wherein the shape of said masks being one among a quadrilateral and a hexagon.

10. The method of any preceding claim further comprised of the sub-pixel array structure including a delta structure.

11. The method of claim 1, wherein said display panel being a plasma display panel.

12. The method of claim 3, further comprised of said laying of said mask not including a next same color sub-pixel.

13. A method of processing image data according to any preceding claim driving wherein said mask does not cover any portion of a next same color sub-pixel area;

14. The method of claim 13, wherein the output image data of a certain sub-pixel generated according to:

$$\frac{\sum_{y=1}^{z} A_y \cdot b_y}{\sum_{y=1}^{z} A_y}$$

where A is an area of a portion of said mask,
where z is the number of portions of said mask, and
where b is the image data of a pixel area including the area A on the first virtual screen.

15. A system for processing image data to generate output image data for driving a display panel, comprising:

a computer processor unit processing the image data;
a computer readable medium storing the image data;
a first unit initializing said computer readable medium;
a second unit setting a new resolution for input image data according to a resolution of said display panel;
a third unit dividing a first virtual screen into a plurality of pixel areas according to said new resolution set for said input image data;
a fourth unit superimposing a second virtual screen including a sub-pixel array structure of said display panel on said first virtual screen;
a fifth unit laying a mask wider than a sub-pixel area on the superimposed second virtual screen on each sub-pixel area;
a sixth unit obtaining and setting an area ratio of the area of each pixel portion on said first virtual screen included in each mask to an area of said mask; and
a seventh unit applying said new resolution and the area ratios to a driving device of said display panel, transforming said input image data having an original resolution into image data having said new resolution, and generating a sum of the results of multiplying area ratios of pixel portions on the first virtual screen in each mask by the transformed image data of the pixel areas, respectively, as output image data of the sub-pixel corresponding to said mask.

16. The system of claim 15, with the output image data of a certain sub-pixel generated according to:

$$\frac{\sum_{y=1}^{z} A_y \cdot b_y}{\sum_{y=1}^{z} A_y},$$

where A is an area of a portion of said mask,
where z is the number of portions of said mask, and
where b is the image data of a pixel area including the area A on the first virtual screen.

17. A system for processing image data to generate output image data for driving a display panel, comprising:

a computer readable medium;
a processor connected to said computer readable medium, said processor programmed to:

setting a new resolution for input image data according to a resolution of said display panel;
dividing a first virtual screen into a plurality of pixel areas according to said new resolution set for said input image data;
superimposing a second virtual screen including a sub-pixel array structure of said display panel on said

first virtual screen;
laying a mask wider than a sub-pixel area on the superimposed second virtual screen on each sub-pixel area;
obtaining and setting an area ratio of the area of each pixel portion on said first virtual screen included in each mask to an area of said mask; and
applying said new resolution and the area ratios to a driving device of said display panel, transforming said input image data having an original resolution into image data having said new resolution, and generating a sum of the results of multiplying area ratios of pixel portions on the first virtual screen in each mask by the transformed image data of the pixel areas, respectively, as output image data of the sub-pixel corresponding to said mask.

18. The system of claim 16 or 17, with the new resolution for the input image data being set to maximize the number of masks having the same area ratio structures.

19. The system of claim 18, with said second unit setting of said new resolution comprising:

setting a new horizontal resolution for said input image data according to a horizontal resolution of said display panel; and
setting a new vertical resolution for said input image data according to a vertical resolution of said display panel.

20. The system of claim 19, with said new horizontal resolution being set to accommodate a ratio of said new horizontal resolution for the input image data to said horizontal resolution of said display panel being one among 1:1, 1.5:1, and 2:1.

21. The system of claim 19, with said new vertical resolution being set to accommodate said new vertical resolution for said input image data to said vertical resolution of said display panel being one among 1:1, 1:2:1, 1.5:1, 1.6:1, and 2:1.

22. The system of claim 21, further comprised of said fourth unit including when said second virtual screen is superimposed on said first virtual screen, the central line of each pixel area on said first virtual screen not being the central line of each sub-pixel area on said second virtual screen.

23. The system of claim 22, further comprised of a shape of said masks being the same as said sub-pixels of said display panel.

24. The system of claim 22, further comprised of a shape of said masks being one among a quadrilateral, a hexagon, and a circle.

25. The system of claim 22, further comprised of a shape of said masks being one among a quadrilateral and a hexagon.

26. The system of claim 25, further comprised of when said second virtual screen is superimposed on said first virtual screen, the central line of each pixel area on said first virtual screen not being the central line of each sub-pixel area on said second virtual screen.

27. The system of any of claims 15 to 26, further comprised of the sub-pixel array structure being a delta structure.

28. The system of any of claims 15 to 27, with said display panel being a plasma display panel.

29. The system of any of claims 15 to 28, further comprised of said laying of said mask not including a next same color sub-pixel.

30. A computer-readable medium having computer-executable instructions for performing a method according to any of claims 1 to 14.

31. A computer-readable medium having stored thereon a data structure comprising:

a first field containing data representing a new resolution for input image data according to a resolution of a plasma display panel;

a second field containing data representing a dividing of a first virtual screen into a plurality of pixel areas according to said new resolution set for said input image data;
a third field containing data representing a superimposing of a second virtual screen including a sub-pixel array structure of said plasma display panel on said first virtual screen;
a fourth field containing data representing laying a mask on the superimposed second virtual screen on each sub-pixel area, said mask not covering any portion of a next same color sub-pixel area;
a fifth field containing data representing obtaining and setting an area ratio of the area of each pixel portion on said first virtual screen included in each mask to an area of said mask; and
a sixth field containing data representing applying said new resolution and the area ratios to a driving device of said plasma display panel, transforming said input image data having an original resolution into image data having said new resolution, and generating a sum of the results of multiplying area ratios of pixel portions on the first virtual screen in each mask by the transformed image data of the pixel areas, respectively, as output image data of the sub-pixel corresponding to said mask.

32. A method of processing image data to generate output image data for driving a plasma display panel, the method comprising:

dividing a first virtual screen into a plurality of pixel areas according to a new resolution generated from an original resolution for said input image data;
superimposing a second virtual screen including a delta type sub-pixel array structure of said plasma display panel on said first virtual screen;
laying a mask wider than a sub-pixel area on the superimposed second virtual screen on each sub-pixel area, said mask not covering a portion of a next same color sub-pixel area;
setting an area ratio of the area of each pixel portion on said first virtual screen included in each mask to an area of said mask; and
applying said new resolution and the area ratios to a driving device of said plasma display panel, transforming said input image data having an original resolution into image data having said new resolution, and generating a sum of the results of multiplying area ratios of pixel portions on the first virtual screen in each mask by the transformed image data of the pixel areas, respectively, as output image data of the sub-pixel corresponding to said mask.

FIG. 1 (RELATED ART)

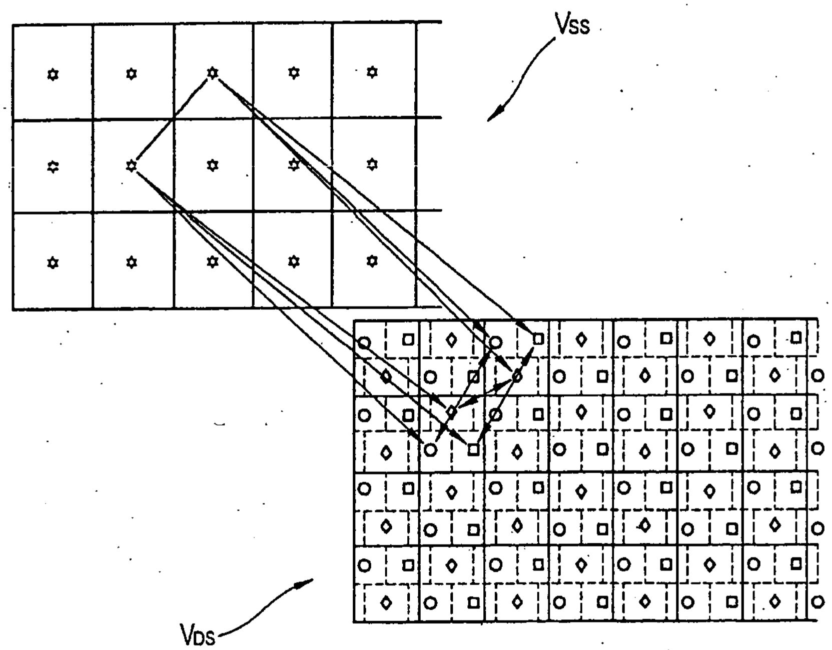


FIG. 2

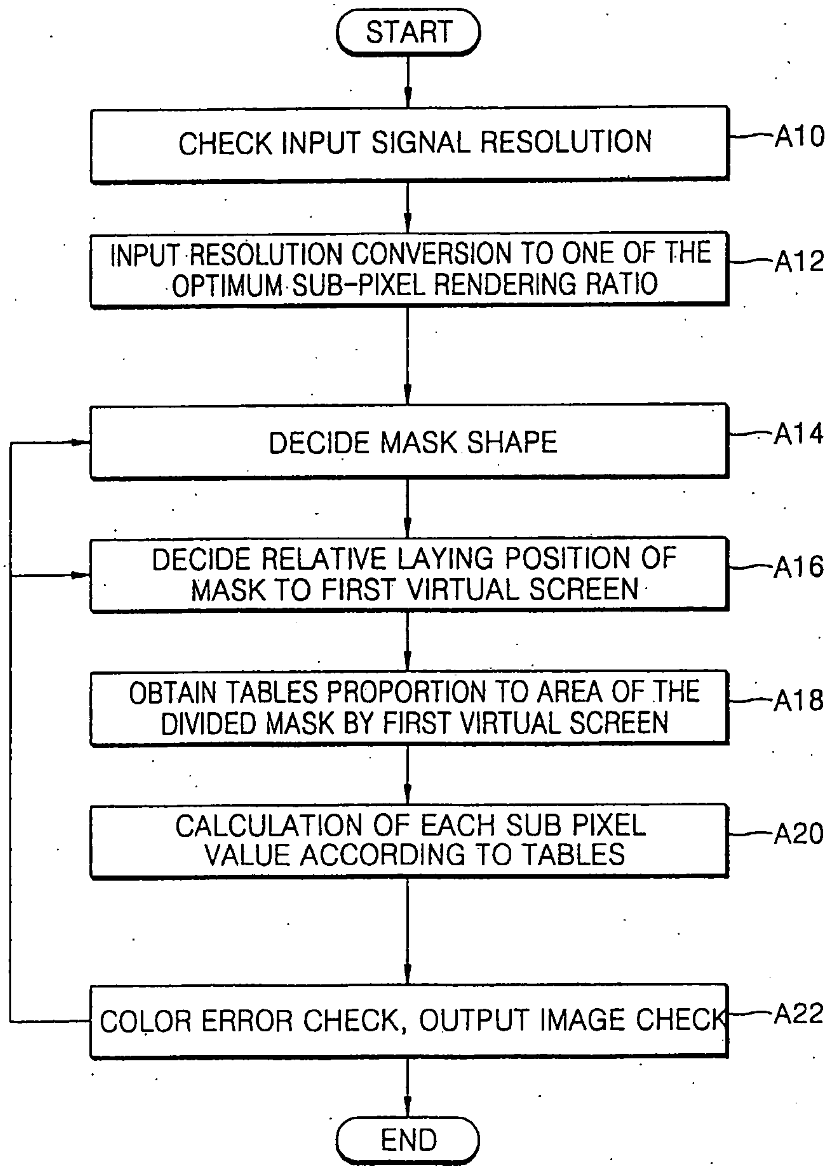

START
CHECK INPUT SIGNAL RESOLUTION
A10
INPUT RESOLUTION CONVERSION TO ONE OF THE OPTIMUM SUB-PIXEL RENDERING RATIO
A12
DECIDE MASK SHAPE
A14
DECIDE RELATIVE LAYING POSITION OF MASK TO FIRST VIRTUAL SCREEN
A16
OBTAIN TABLES PROPORTION TO AREA OF THE DIVIDED MASK BY FIRST VIRTUAL SCREEN
A18
CALCULATION OF EACH SUB PIXEL VALUE ACCORDING TO TABLES
A20
COLOR ERROR CHECK, OUTPUT IMAGE CHECK
A22
END

FIG. 3

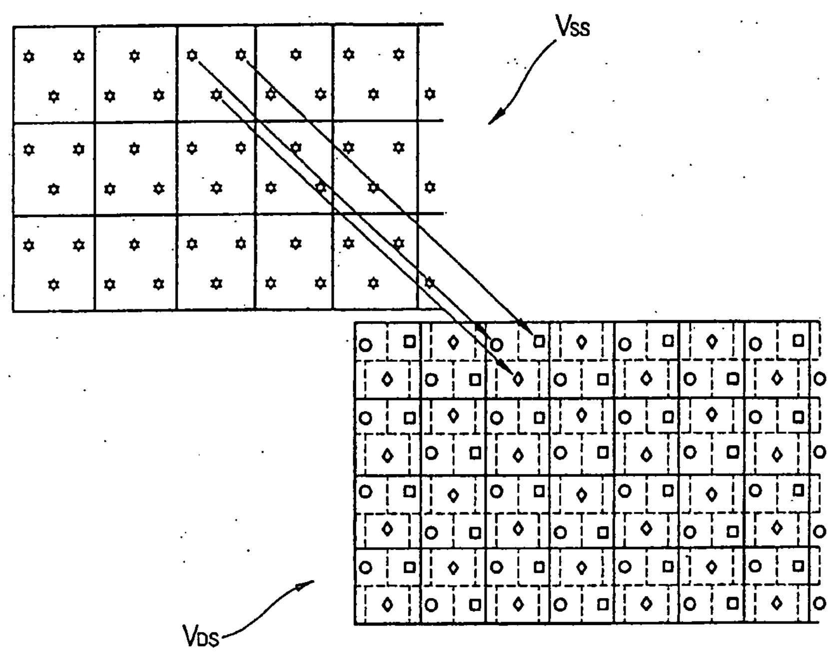


FIG. 4

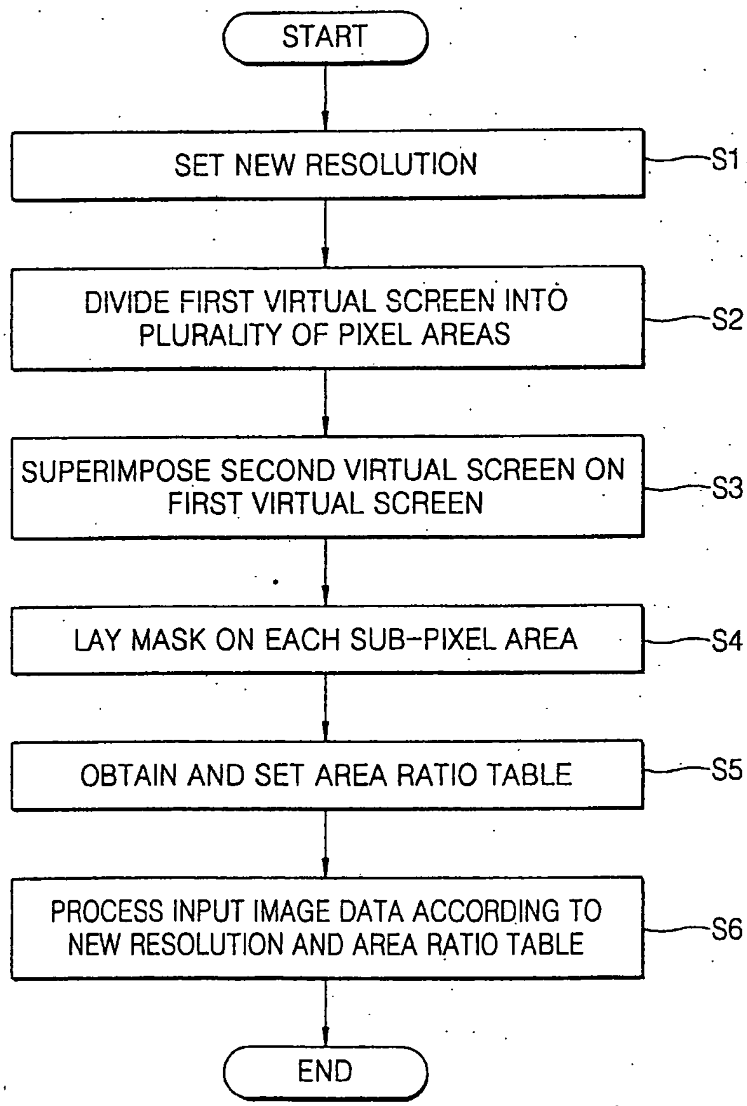

START
SET NEW RESOLUTION
S1
DIVIDE FIRST VIRTUAL SCREEN INTO PLURALITY OF PIXEL AREAS
S2
SUPERIMPOSE SECOND VIRTUAL SCREEN ON FIRST VIRTUAL SCREEN
S3
LAY MASK ON EACH SUB-PIXEL AREA
S4
OBTAIN AND SET AREA RATIO TABLE
S5
PROCESS INPUT IMAGE DATA ACCORDING TO NEW RESOLUTION AND AREA RATIO TABLE
S6
END

FIG. 5

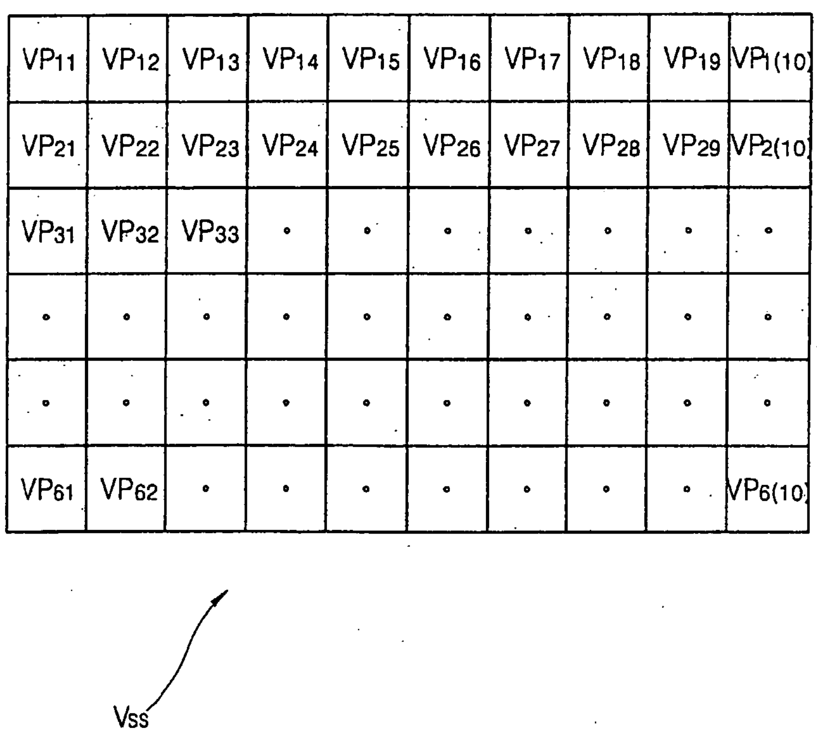

VP11
VP12
VP13
VP14
VP15
VP16
VP17
VP18
VP19
VP1(10)
VP21
VP22
VP23
VP24
VP25
VP26
VP27
VP28
VP29
VP2(10)
VP31
VP32
VP33
VP61
VP62
VP6(10)
Vss

FIG. 6

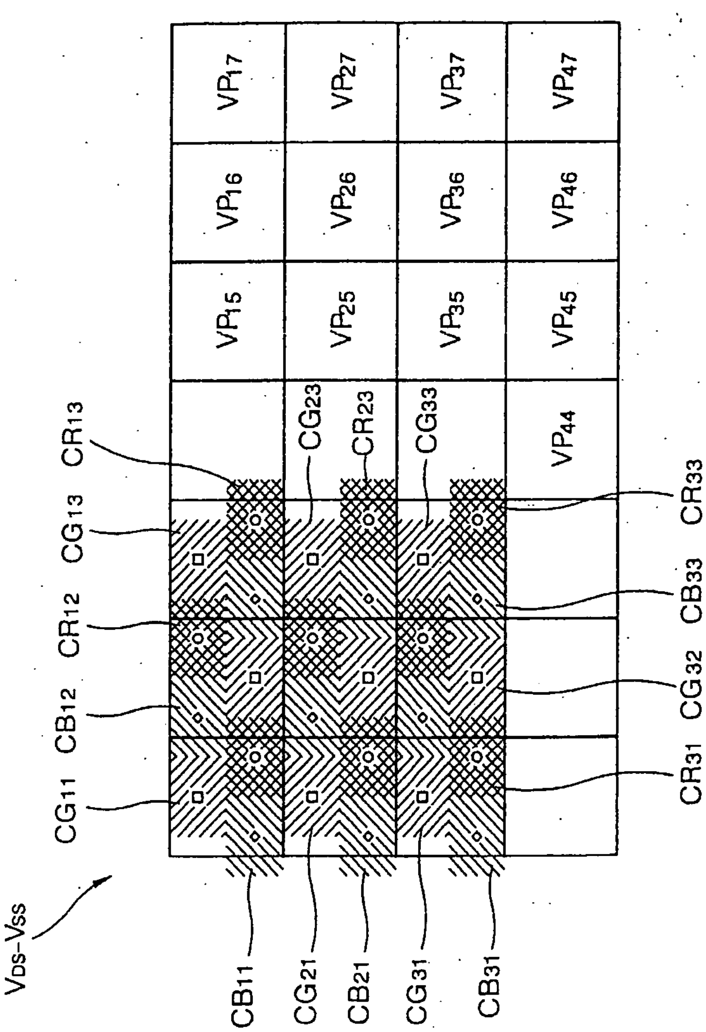

V_{DS}-V_{SS}
CG_{11}
CB_{12}
CR_{12}
CG_{13}
CR_{13}
CG_{23}
CR_{23}
CG_{33}
VP_{44}
VP_{15}
VP_{25}
VP_{35}
VP_{45}
VP_{16}
VP_{26}
VP_{36}
VP_{46}
VP_{17}
VP_{27}
VP_{37}
VP_{47}
CR_{33}
CB_{33}
CG_{32}
CR_{31}
CB_{11}
CG_{21}
CB_{21}
CG_{31}
CB_{31}

FIG. 7

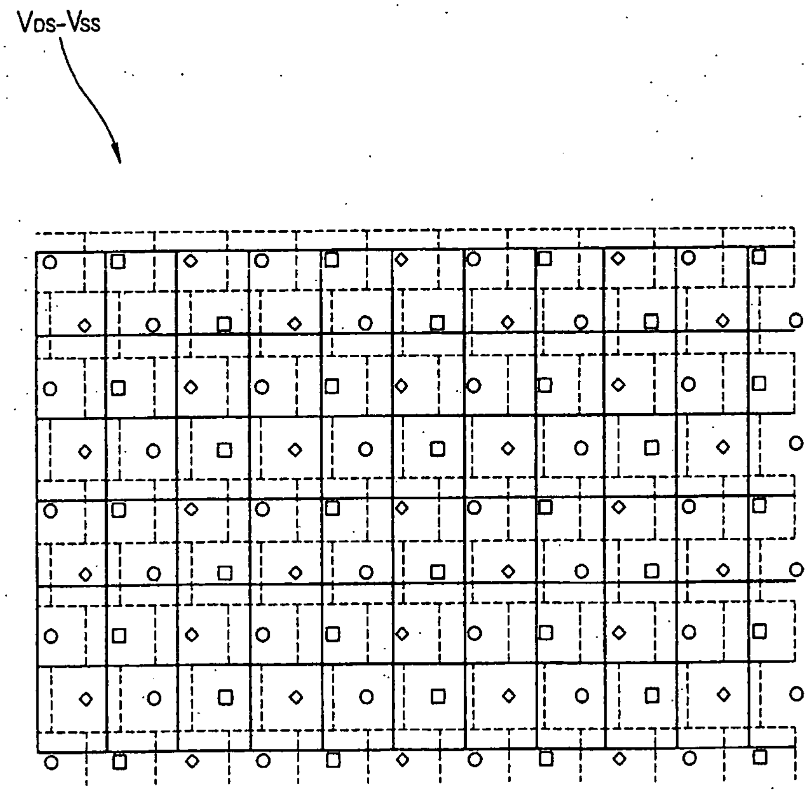


FIG. 8A

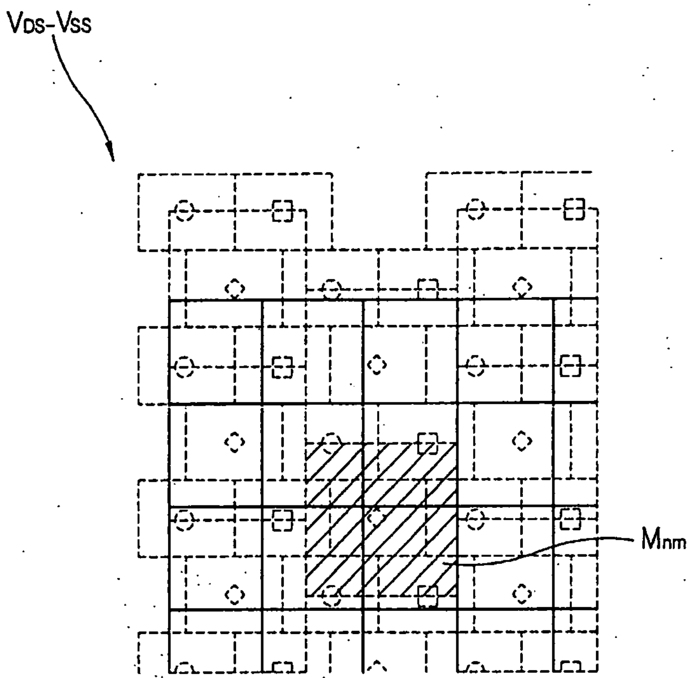


FIG. 8B

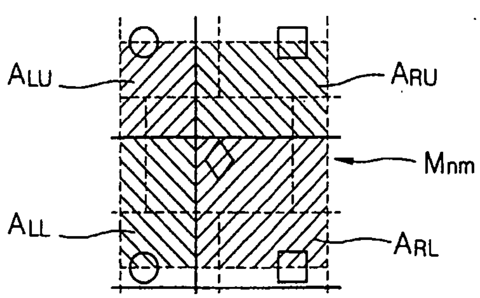


FIG. 9A

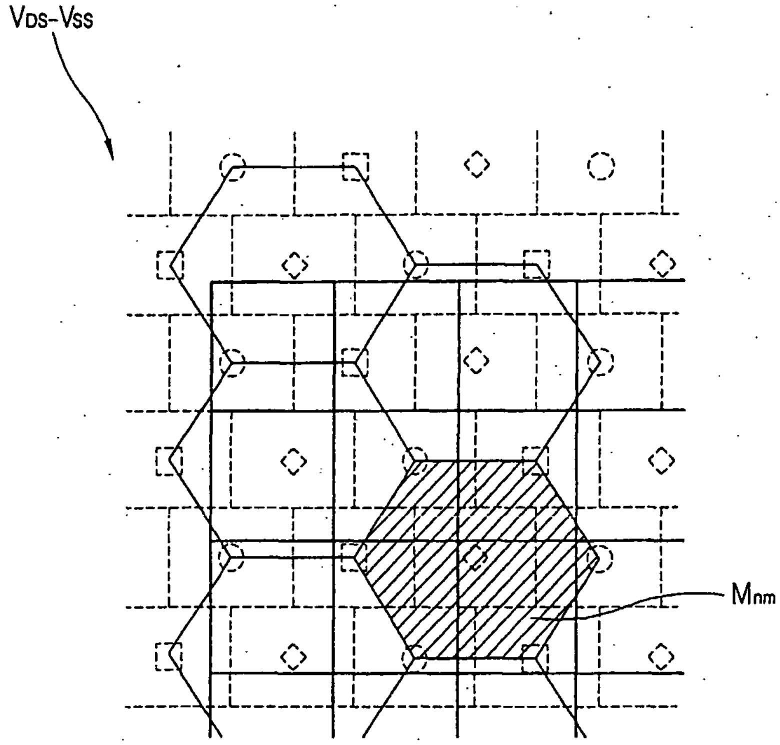


FIG. 9B

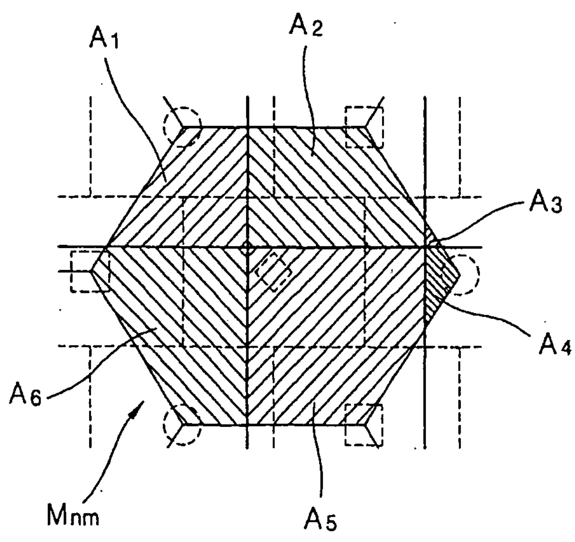


FIG. 10A

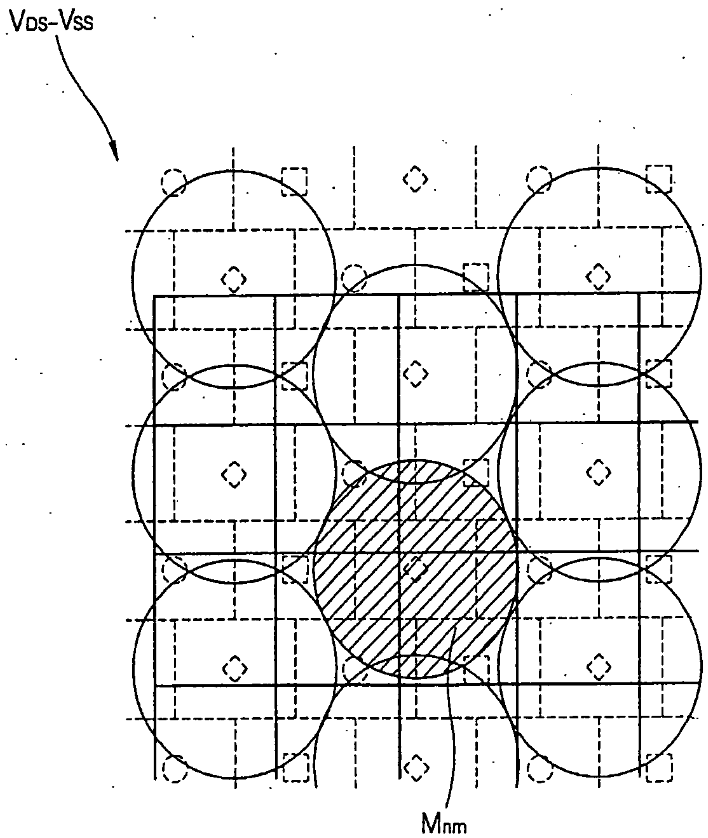


FIG. 10B

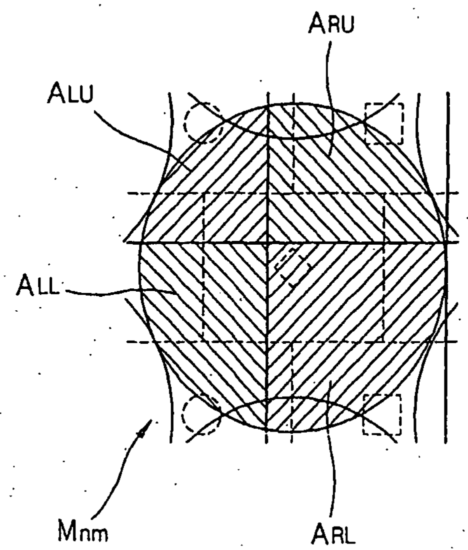


FIG. 11

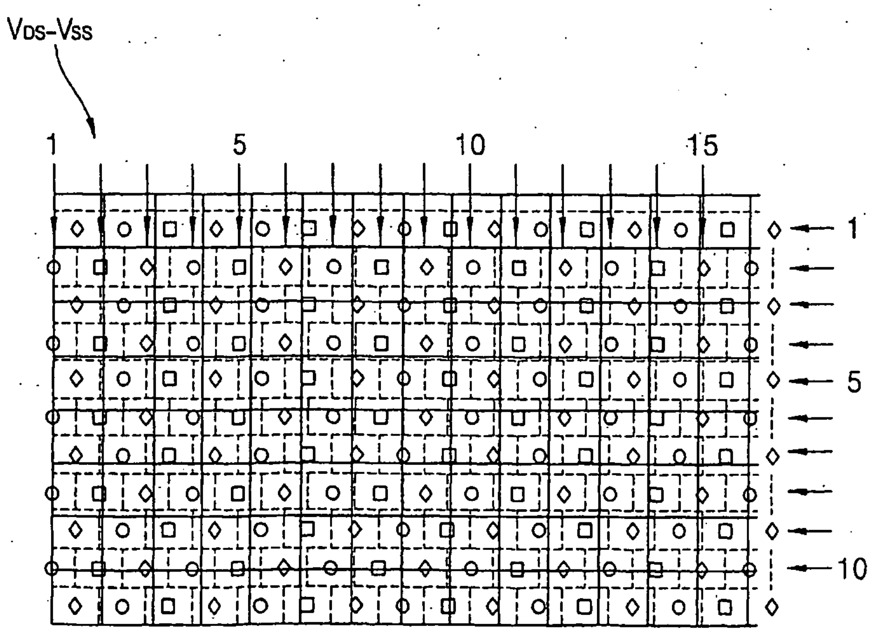


FIG. 12

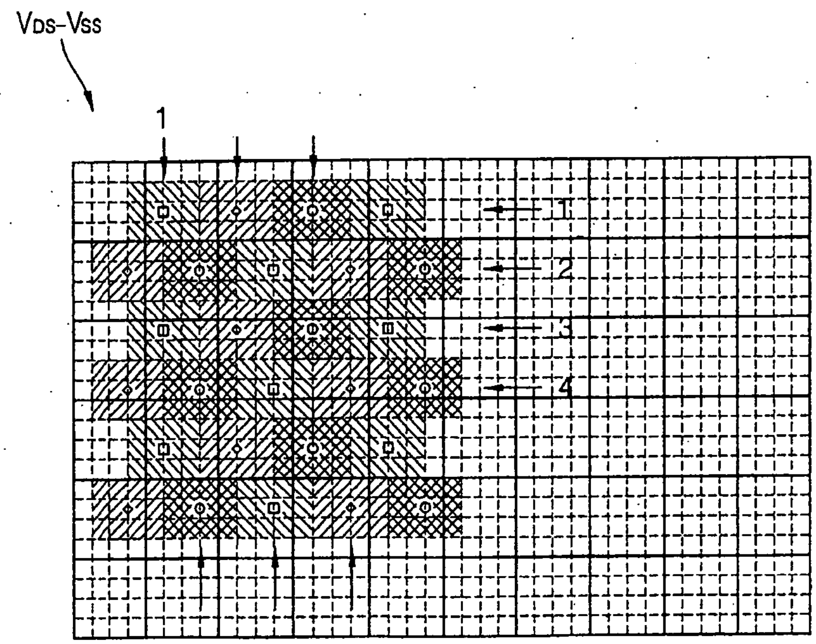


FIG. 13A

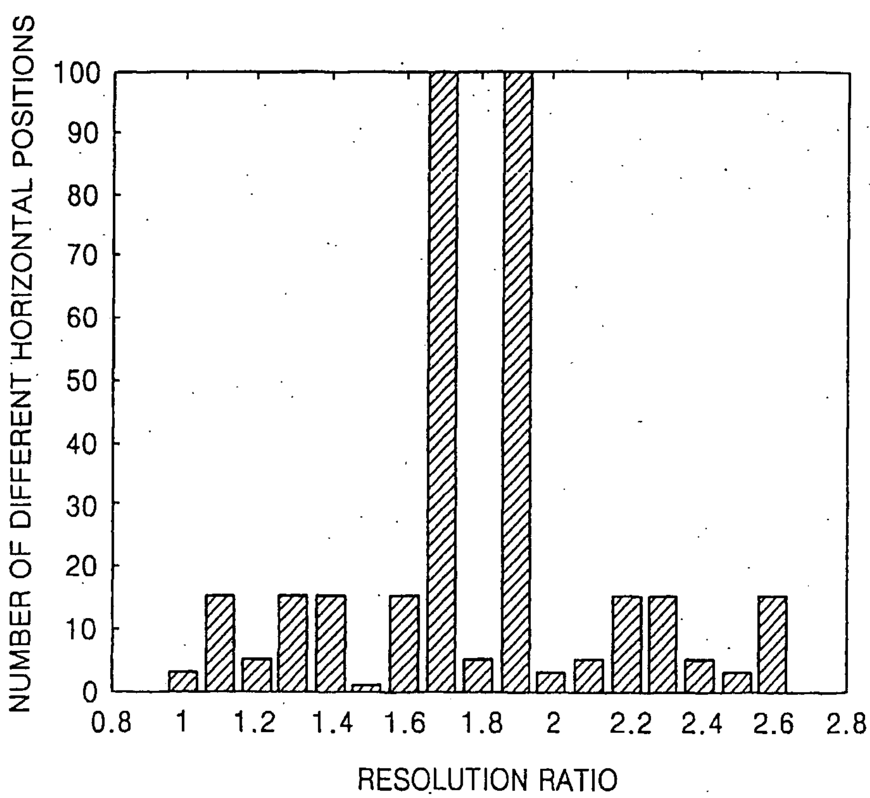

NUMBER OF DIFFERENT HORIZONTAL POSITIONS
100
90
80
70
60
50
40
30
20
10
0
0.8
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8
RESOLUTION RATIO

FIG. 13B

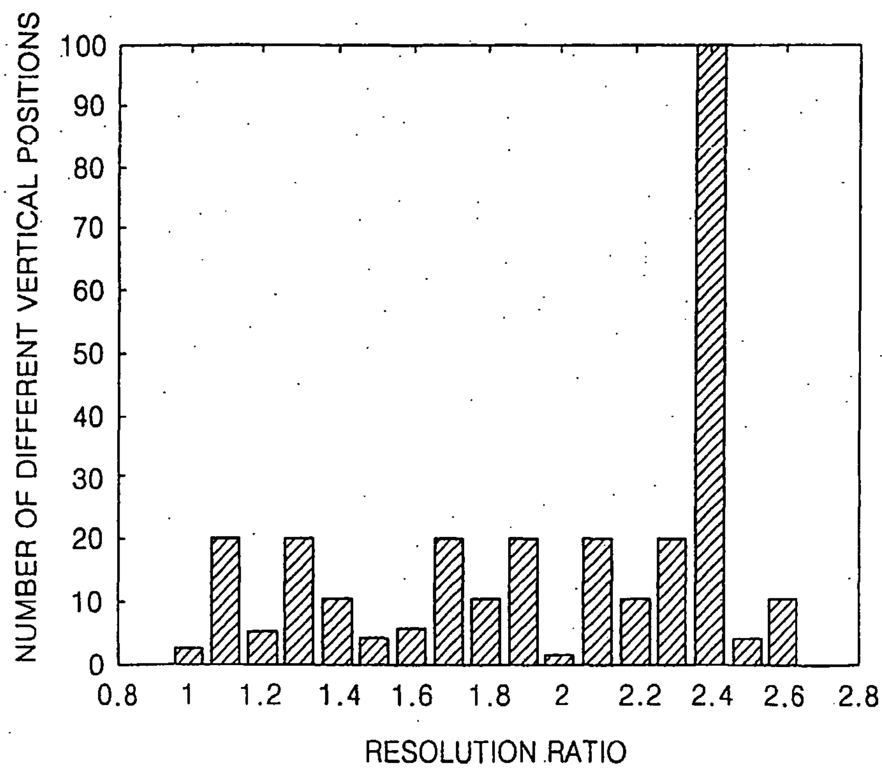

NUMBER OF DIFFERENT VERTICAL POSITIONS
100
90
80
70
60
50
40
30
20
10
0
0.8
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8
RESOLUTION RATIO

FIG. 14

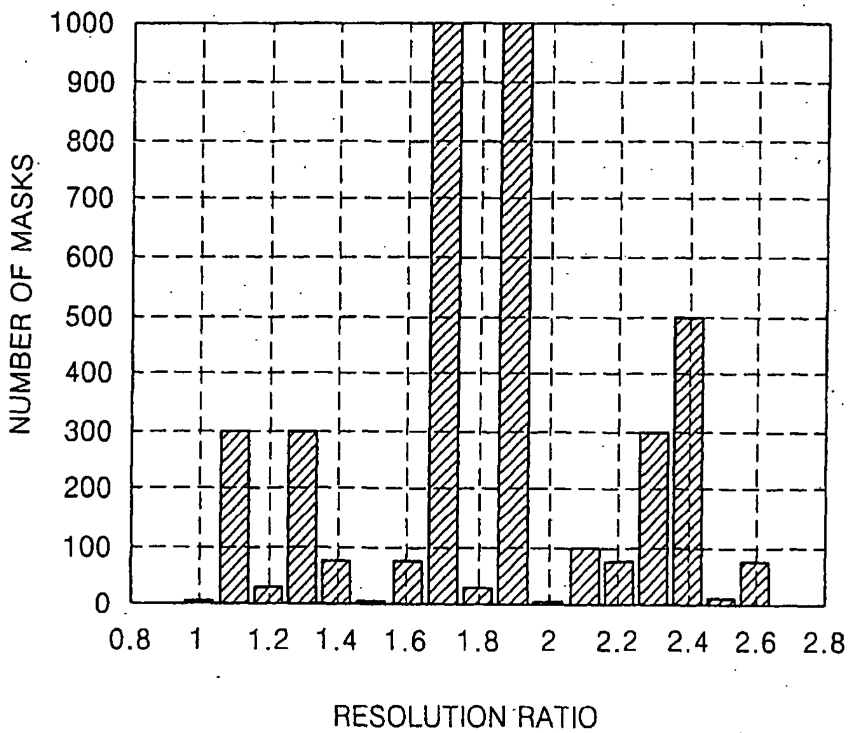

1000
900
800
700
600
500
400
300
200
100
0
NUMBER OF MASKS
0.8
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8
RESOLUTION RATIO

FIG. 15

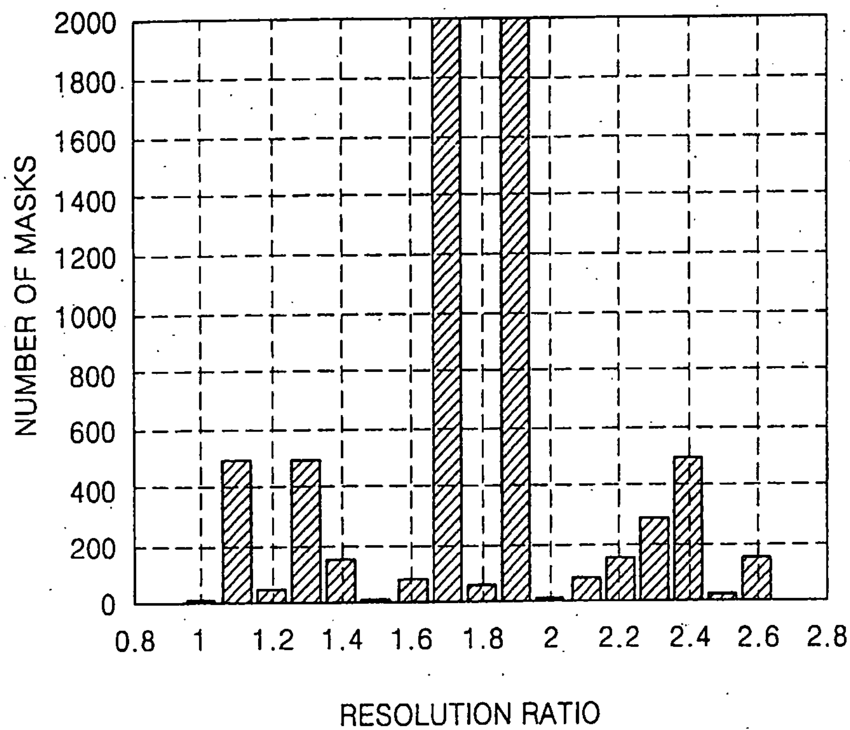

2000
1800
1600
1400
1200
1000
800
600
400
200
0
NUMBER OF MASKS
0.8
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8
RESOLUTION RATIO

FIG. 16A

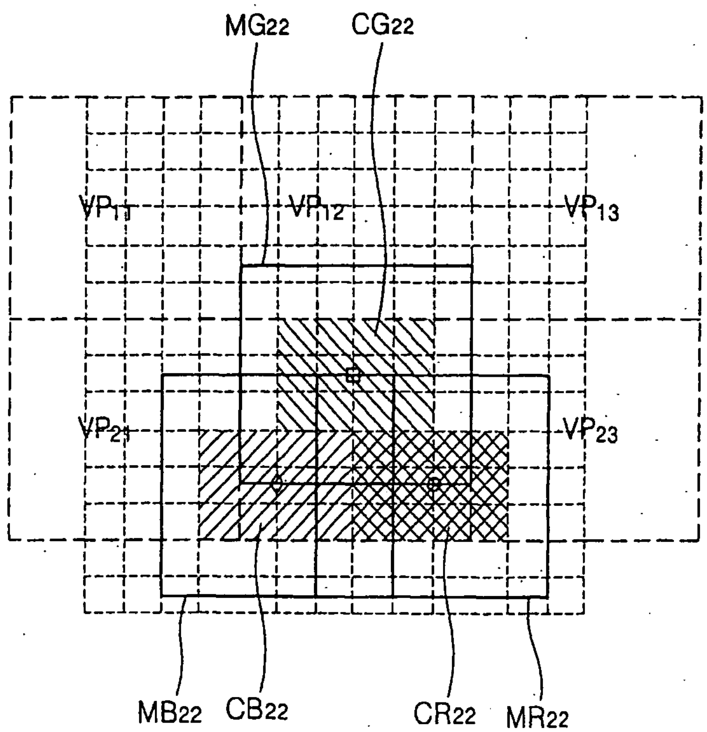


FIG. 16B

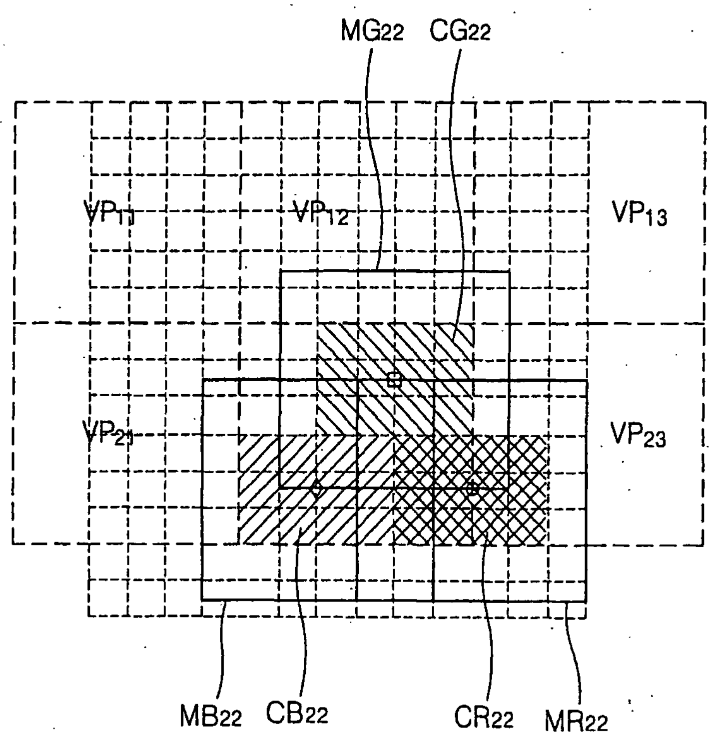


FIG. 17

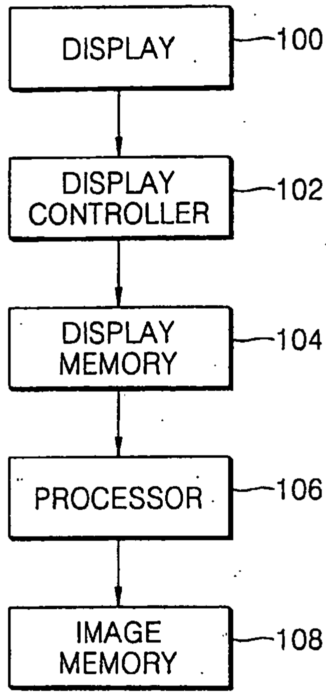

DISPLAY
100
DISPLAY CONTROLLER
102
DISPLAY MEMORY
104
PROCESSOR
106
IMAGE MEMORY
108

FIG. 18

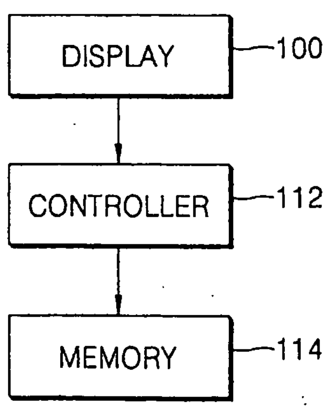
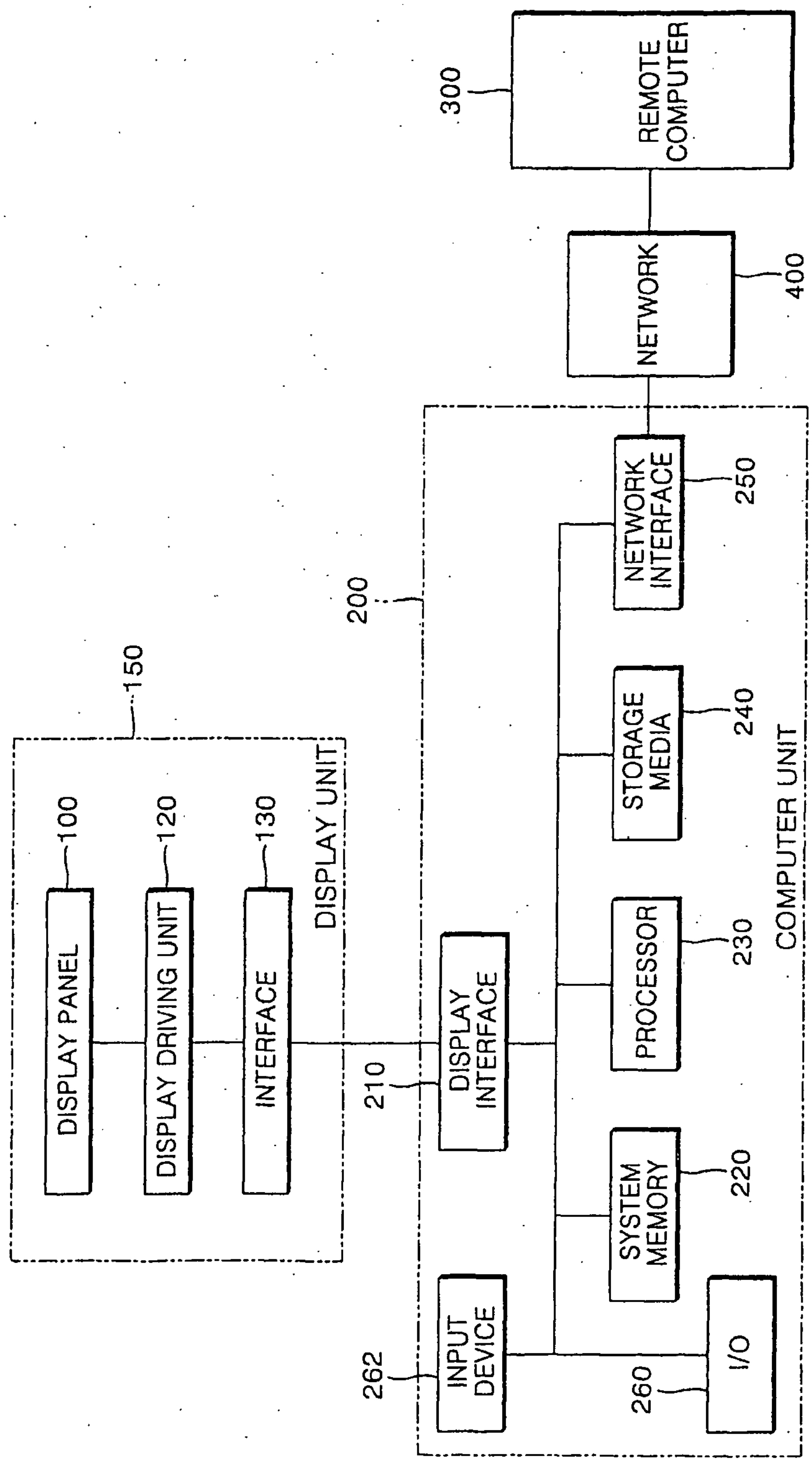

DISPLAY
100
CONTROLLER
112
MEMORY
114

FIG. 19


DISPLAY PANEL
100
DISPLAY DRIVING UNIT
120
INTERFACE
130
DISPLAY UNIT
150
200
DISPLAY INTERFACE
210
SYSTEM MEMORY
220
PROCESSOR
230
STORAGE MEDIA
240
NETWORK INTERFACE
250
COMPUTER UNIT
INPUT DEVICE
262
I/O
260
NETWORK
400
REMOTE COMPUTER
300